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Dietary supplement use among elderly, long-term cancer survivors

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Abstract

Introduction—The purpose of the present study was to assess dietary supplement use and its association with micronutrient intakes and diet quality among older (≥65y), long-term survivors (≥5 years post-diagnosis) of female breast, prostate, and colorectal cancer.

Methods—The sample included 753 survivors who participated in telephone screening interviews to determine eligibility for a randomized diet and physical activity intervention trial entitled RENEW: Reach-out to ENhancE Wellness in Older Cancer Survivors. Telephone surveys included two 24-hour dietary recalls and items regarding supplement use (type, dose, and duration). Nutrient intakes were compared to Dietary Reference Intakes (DRIs). Diet quality was assessed using the revised Healthy Eating Index (HEI). Descriptive statistics and multivariate logistic regression were used in this cross-sectional study.

Results—A majority of survivors (74%) reported taking supplements, with multivitamins (60%), calcium/vitamin D (37%), and antioxidants (30%) as the most prevalent. Overall proportions of the total sample with dietary intakes below Estimated Average Requirements (EARs) were substantial, although supplement users had more favorable mean HEI scores ($P<0.01$) and nutrient intakes for 12 of the 13 vitamins and minerals investigated (P-values <0.05). Supplement use was positively associated with older age (≥70 years) (odds ratio (OR) 1.70; 95% confidence interval (95% CI) 1.17, 2.46) and female gender (OR 1.49; 95% CI 1.04, 2.13), and negatively associated with current smoking (CI 0.40, 95% CI 0.21, 0.76). Individuals scoring higher on the Total Fruit (OR 1.12, CI 1.01, 1.23), Whole Grain (OR 1.14, CI 1.04, 1.25), and Oil (OR 1.10, CI 1.01, 1.11) components of the HEI were significantly more likely to take supplements, while those scoring higher on the Meat and Beans category (OR 0.81, CI 0.71, 0.93) were significantly less likely to take supplements. Compared to those with less than a high school education, survivors with a professional or graduate degree were significantly more likely to use supplements (OR 2.18, CI 1.13, 4.23).

Discussions/Conclusions—Demographic, disease, and health-related correlates of supplement use follow similar trends observed in the general population as well as previous reports from other cancer survivor populations. Supplement use may reduce the prevalence of nutrient inadequacies in this population, though survivors who use supplements are the least likely to need them.

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Implications for Cancer Survivors—Supplement use may be an effective means for many survivors to achieve adequate nutrient intakes; however, open communication between healthcare providers and survivors is needed to ensure potential concerns are addressed as supplement use may not always be beneficial.

Keywords

Dietary Supplements; Vitamins; Minerals; Long-Term Survivors; Elderly

Introduction

Cancer survival rates are rising along with the population of older adults in the United States [1], leading to an expanding population of elderly (≥65y), long-term cancer survivors, a group at increased risk for progressive, recurrent, and secondary cancer, osteoporosis, obesity, cardiovascular disease, diabetes, and functional decline [2-5]. Elderly cancer survivors may initiate diet, physical activity, and other lifestyle changes post-diagnosis in an attempt to prevent recurrence or other chronic disease, or improve overall health and quality of life [2,3,5,6]. One of the most common changes in behavior among cancer survivors is the use of new dietary supplements [5], a broad category of products including vitamins, minerals, herbs or other botanicals, amino acids, glandular extracts, or other non-nutrient ingredients [7]. Despite widespread use of dietary supplements, their role in promoting health and preventing cancer recurrence, secondary cancers, and other chronic diseases remains unclear. According to the National Institutes of Health (NIH) [8], the state of the scientific evidence is insufficient to establish firm recommendations concerning the use of multivitamin-multimineral (MVMM) supplements for chronic disease prevention in the general population.

Nevertheless, several potential beneficial roles for dietary supplements have been suggested. A daily MVMM supplement supplying nutrients at or below recommended intake levels is generally considered an effective approach to increase the prevalence of nutrient intake adequacy among adults [9,10]. Older adults in particular may have compromised nutrient intakes resulting from a variety of factors [11], including but not limited to functional or financial constraints [12,13], acute and chronic illnesses, medication use [14], oral health concerns [15], or various environmental barriers [13]. Diminished absorption and utilization of nutrients concomitant with aging or medication use also may exacerbate existing intake inadequacies [16]. In addition to potential benefits of MVMM use, calcium and vitamin D supplementation have been found to slow bone loss associated with cancer treatment [17] as well as aging [18].

At the other end of the spectrum, a growing body of evidence suggests that the use of various dietary supplements in some cases could pose health-related risks [19-28]. For example, a recent investigation found an increased risk of advanced and fatal prostate cancer among older men who used MVMM supplements more than seven times per week compared to never users [28]. Overall, very little is known concerning the efficacy and safety of use of most dietary supplements [29]. The use of supplements may result in nutrient intakes surpassing the Tolerable Upper Intake Levels (ULs) established by the Institute of Medicine of the National Academy of Sciences (IOM/NAS) [30-33]. However, few studies have explored the use of dietary supplements among elderly, long-term cancer survivors.

Characterizing supplement use patterns is an important step in accurately evaluating the associated health benefits and risks of supplement use. With older age as a leading risk factor for cancer and compromised nutrient intakes more likely among older adults, a better understanding of dietary supplement use among elderly, long-term cancer survivors is of particular interest. Further, as financial resources may be limited among older adults [12,13],

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dietary supplement and food purchasing decisions become increasingly important. The primary aim of this study was to assess dietary supplement use and its association with micronutrient intakes and diet quality within a population of older (≥65y), long-term survivors (≥5 years post-diagnosis) of female breast, prostate, and colorectal cancer.

Methods

Study sample

Participants included 753 older survivors (≥65y) at least 5 years removed from a diagnosis of female breast, prostate, or colorectal cancer who completed extensive screening measures for a randomized controlled trial entitled Reach out to ENhancE Wellness in Older Cancer Survivors (RENEW), a study designed to test the efficacy of a home-based diet and physical activity intervention aimed at improving the physical functioning of older survivors. The Institutional Review Boards at both Duke University Health System and the Pennsylvania State University approved the research protocol. Survivors were identified for this study via the North Carolina Central Cancer Registry (NCCCR) and previously established physician referral networks, described in detail elsewhere [34]. To be considered eligible for this trial, individuals also had to be community-dwelling, English-speaking and writing, overweight (BMI ≥25 kg/m^2) but not morbidly obese (BMI <40 kg/m^2), with no pre-existing medical or physical conditions that would preclude adherence to an unsupervised diet and physical activity program (i.e., unstable angina, congestive heart failure, end-stage renal disease, severe orthopedic conditions, etc).

Eligible individuals participated in two telephone interviews administered by the Diet Assessment Center at the Pennsylvania State University. All individuals who completed the telephone interviews as a part of the screening process for RENEW were included in the exploratory analysis (n=753) discussed here, which included survivors of female breast (n = 321), prostate (n = 319), and colorectal (n = 113) cancer residing across North America. Since individuals who reported exercising 150 minutes or more per week were excluded from participation, only 641 of these survivors ultimately were enrolled in RENEW. Chi-square analyses revealed that men were more likely to screen out of RENEW as a result of reporting 150 minutes or more of moderate to vigorous physical activity each week. No other statistically significant differences were noted between the RENEW trial sample and the full sample discussed here.

Demographic, disease, and health-related characteristics

Demographic and disease-related data including the type of cancer, date of diagnosis, cancer stage, age, race, and gender were provided by the NCCCR for a large majority of cases and by the oncology care physician for self-referred individuals. More detailed participant information was collected by interviewers during the two baseline computer-assisted telephone interviews. Questions pertaining to the presence of co-morbid conditions, the type of cancer treatment, body weight, height, physical functioning, and general health or quality of life perceptions were asked in conjunction with two 24-hour dietary recalls. Physical activity data were ascertained via the telephone-adapted Community Health Activities Model Program (CHAMPS) questionnaire, a previously validated tool for use among older adults [35].

Dietary and supplemental intake

Dietary intake and supplement use data were obtained from two unannounced 24-hour recalls performed by trained interviewers at the Diet Assessment Center at the Pennsylvania State University. Previous research has shown 24-hour dietary recalls performed over the telephone to be a practical and valid data collection tool [36]. Interviewers collected dietary intake data using the interactive Nutrition Data System-Revised (NDS-R) software (NCC Food and

Nutrient Database System Version 2006, Nutrition Coordinating Center, Minneapolis, MN). During the dietary recall interviews, participants were asked to indicate if they had taken any dietary supplements the previous day. Individuals reporting the use of at least one supplement on one of the two 24-hour dietary recalls were defined as supplement users, while those who did not indicate the use of any dietary supplement were defined as nonusers. Supplement users were asked to list any supplements taken the previous day and the duration of use for each supplement. Product name was collected for MVMM supplements and other combination preparations, and specific dose was recorded for the remaining supplements reported, including single vitamin, mineral, and herbal supplements.

Dietary supplements were grouped into 12 categories: 1) MVMM products, 2) single calcium, calcium-containing antacids, calcium combination supplements, and single vitamin D, 3) antioxidants (carotenoids, vitamin C, vitamin E, selenium, and related combinations), 4) herbal and other botanical supplements, 5) other single vitamins, 6) other single minerals, 7) other vitamin combinations, 8) other mineral combinations, 9) fatty acids, fish oils, and other oils, 10) glucosamine, chondroitin, and related combinations, 11) amino acids, nucleic acids, and proteins including co-enzymes and 12) fiber supplements (various types).

Several conversions to standardized units were made before adding nutrient values from supplements to dietary intakes. Milligrams of supplemental folic acid were multiplied by a factor of 1.7 to convert to dietary folate equivalents (DFE). Supplemental vitamin A and beta-carotene recorded in International Units (IU) were multiplied by factors of 0.3 and 0.15, respectively, to convert to retinol activity equivalents (RAE). Supplemental vitamin E recorded in IU was considered to be the synthetic form, *all rac-α*-tocopherol, and was converted to *α*-tocopherol equivalents (TE) by a factor of 0.45. Vitamin D recorded in IU was divided by a factor of 40 to determine the equivalent amount in micrograms (mcg). Intake from MVMM formulations, eye-health antioxidant combination formulas, and general antioxidant combination supplements were estimated by using default nutrient profiles of the most commonly reported products: Centrum Silver (Wyeth Consumer Healthcare, Madison, NJ), Ocuvite PreserVision AREDS Formula for Macular Degeneration (Bausch & Lomb, Rochester, NY), and Spring Valley Antioxidant Formula with Minerals (Nature's Bounty, Inc, Bohemia, NY).

Overall diet quality was measured by the revised Healthy Eating Index (HEI) [37], a food-derived assessment tool consisting of twelve individual scored components that sum to a maximum score of 100 (best) and a minimum score of zero (worst). The following six components have a maximum score of five: Total Fruit, Whole Fruit, Total Vegetables, Dark Green and Orange Vegetables and Legumes, Total Grains, and Whole Grains. Milk, Oil, Meat and Beans, Sodium, and Percent Calories from Saturated Fat have a maximum score of 10. The remaining component of Calories from Solid Fat, Alcohol, and Added Sugar has a maximum score of 20.

Comparisons to Dietary Reference Intakes

Nutrient intake estimates were generated in three ways: 1) from dietary intake alone for nonusers of supplements; 2) from dietary intake alone for users of supplements; and 3) from dietary combined with supplemental intake for users. The Estimated Average Requirement (EAR) cut-point method was used to estimate the prevalence of nutrient intake inadequacy [38]. With the cut-point method, the prevalence of inadequate nutrient intake is the proportion of the population with usual intake levels below the average requirement (EAR). Estimates of proportions of individuals meeting Adequate Intakes (AIs) were generated for nutrients without EARs established by the IOM/NAS; however, these estimates were not used to assess the prevalence of nutrient inadequacy, as AIs were not developed for this purpose [38]. Rather, the proportion of our sample meeting the AI for each respective vitamin or mineral without an

EAR was considered to have nutrient intakes that were most likely adequate. Comparisons to ULs were used to estimate the proportion of survivors at risk for adverse health effects from elevated nutrient intakes [30-33].

Statistical analyses

Dietary supplement users were defined as participants reporting the use of at least one supplement on one of the two 24-hour dietary recalls. Student's t-tests and chi-square tests were used to compare supplement users and nonusers on demographic, lifestyle, and health-related characteristics. Multivariate logistic regression was performed to identify significant predictors of supplement use. The dependent variable of supplement use was dichotomous (use/nonuse). All characteristics significantly associated with supplement use from bivariate chi-square analyses were entered as candidate predictor variables in regression analysis (i.e., age, gender, cancer type, education, tobacco use, total HEI score, and individual HEI component scores of interest). A P-value of ≤ 0.05 was considered statistically significant for all statistical tests. All data were analyzed using SAS version 9.1.3 (2007, SAS Institute Inc, Cary, NC).

Results

Sample description

A total of 753 individuals were included in the final sample. Study participants were predominantly white, well-educated, and from moderate income households. Age ranged from 65 to 87 years, with a median of 73 years. The mean years from diagnosis of survivors at the time of the telephone screening was 8.5 ± 2.6 years. Slightly less than one-half of participants reported no moderate or vigorous physical activity each week. Additional demographic, disease and health-related characteristics of the total sample are presented in Table 1.

Supplement use

Dietary supplement use was common in our study (74%). Use of supplements was more prevalent among breast cancer survivors, as well as non-smoking survivors and individuals with higher levels of educational attainment (P-values <0.05). Table 2 presents the frequency of use by categories of supplements. MVMM products were the most commonly reported supplement, followed by calcium/vitamin D, antioxidants, fatty acids/oils, glucosamine/chondroitin, and herbal/botanical supplements. The median number of formulations reported was two, with a range from one to 25 formulations. Ninety percent of supplement users reported using at least one formulation for greater than one year, 54% for five or more years, and 19% for ten or more years.

Comparisons to Dietary Reference Intakes

Comparisons of the proportions of nonusers versus users below EARs prior to the addition of nutrients from dietary supplements are shown in Table 3 (supplement nonusers vs. supplement users: dietary sources only), along with comparisons of the proportions of nonusers versus users after consideration of nutrients from supplements (supplement nonusers vs. supplement users: dietary + supplemental intake). Although smaller proportions of supplement users compared to nonusers had dietary intakes below EARs, overall proportions of the total sample with dietary intakes below EARs for the following vitamins and minerals were substantial: vitamin E (82%), magnesium (80%), vitamin C (51%), vitamin A (48%), vitamin B6 (43%), zinc (42%), and folate (28%). Consideration of micronutrients from supplements substantially reduced proportions of users below EARs, most notably for vitamins A, B6, C, and E, magnesium, and zinc.

Table 4 presents proportions of survivors meeting AIs for vitamins D and K, calcium, and potassium, four micronutrients for which available data were insufficient or inconclusive for the IOM/NAS to determine EARs. Comparisons of nonusers and users prior to the consideration of dietary supplements are presented, along with comparisons after the addition of nutrients to dietary intake estimates. Very small proportions of both users and nonusers met AIs from diet alone. Consideration of micronutrient contributions from supplements considerably increased proportions of users meeting AIs for calcium and vitamin D, but not vitamin K or potassium.

Overall, small proportions of users had intakes exceeding ULs (Tables 3 and 4). Approximately 10% of users exceeded the UL for zinc, while 4% or less of users exceeded the ULs for vitamins A, B6, C, and D, folic acid, calcium, iron, and magnesium. No individuals exceeded the UL for vitamin E, and to date, no ULs have been established by the IOM/NAS for vitamins B12 and K, or potassium.

Factors associated with supplement use

All characteristics significantly associated with supplement use in bivariate analyses (e.g. age, gender, cancer type, education, tobacco use, total HEI score, and individual HEI component scores of interest) were entered as candidate predictor variables in multivariate logistic regression analysis. As shown in Table 5, results indicated that supplement use was positively associated with older age (≥70 years) (OR 1.70; 95% CI 1.17, 2.46) and female gender (OR 1.49; 95% CI 1.04, 2.13), and negatively associated with current smoking (CI 0.40, 95% CI 0.21, 0.76). Individuals scoring higher on the Total Fruit (OR 1.12, CI 1.01, 1.23), the Whole Grain (OR 1.14, CI 1.04, 1.25), and the Oil (OR 1.10, CI 1.01, 1.11) components of the HEI were significantly more likely to take supplements, while those scoring higher on the Meat and Beans category (OR 0.81, CI 0.71, 0.93) were significantly less likely to take supplements. Compared to those with less than a high school education, survivors with a professional or graduate degree were significantly more likely to use supplements (OR 2.18, CI 1.13, 4.23).

Discussion

In this sample of older, long-term cancer survivors, a majority (74%) reported taking dietary supplements, ranging from 70% among survivors of colorectal cancer to 80% among breast cancer survivors. The prevalence found in this study is comparable to other previously reported estimates of supplement use among cancer survivors [39], but notably higher than estimates of supplement use among healthy older adults aged 60 years and above (63%) (1999-2000 NHANES) [40]. While the observation of greater prevalence of use among older adults and cancer survivors has been reported previously, our study is the first to target older survivors at least five years removed from a cancer diagnosis.

A wide variety of supplements were taken by participants, although MVMM products (60%), calcium/vitamin D (37%), antioxidants (30%), fatty acids/oils (21%), and glucosamine/chondroitin (14%) were more prevalent. The three most commonly reported supplements in our study are similar to the most frequently reported supplements in prior investigations [40-44]; however, larger proportions of survivors in our study used fatty acids/oils and glucosamine/chondroitin.

Similar to findings from other surveys and studies [41,45-48], our data suggest that supplement use is associated with several demographic, disease, and health-related characteristics, and it may serve as a marker for a range of other health-related behaviors, evidenced by lower prevalence rates of smoking and higher scores on measures of diet quality. While our study is the first to explore associations between the revised HEI [37] and supplement use, other investigations have found supplement users to have higher diet quality scores [49,50] using the prior HEI [51]. Associations found between the food-derived HEI and supplement use support previous findings revealing higher intakes of fruits, vegetables, and fiber, and lower intakes of saturated fat by supplement users [6,47,49]. Although supplement use has tracked with higher levels of physical activity and lower rates of overweight and obesity in previous investigations [40,41,52], supplement users and nonusers in our study presented with similar distributions of BMI and physical activity. In light of the initial RENEW screening measures ensuring that older adults in our study were either overweight or obese, as well as the previously observed association of higher BMI levels and lower levels of physical activity among older adults [53,54], some of the more active cancer survivors were likely excluded from our sample.

Consideration of micronutrient contributions from dietary supplements substantially reduced proportions of individuals below EARs for most micronutrients, including vitamins A, C, E, and B6, folate, magnesium, and zinc, paralleling findings from previous investigations [9,10, 46]. Dietary intakes of vitamin B12 and iron were sufficient for a vast majority of survivors before consideration of dietary supplements. It is important to note that despite improvements in magnesium intake after consideration of supplemental intake, 40% of users remained below the EAR.

Overall, very few individuals met AIs for calcium, vitamin D, potassium, and vitamin K from diet alone. Supplemental intake considerably increased proportions of supplement users above AIs for calcium (6% to 37%) and vitamin D (3% to 55%), but did not sizably increase proportions above AIs for potassium (1% to 2%) or vitamin K (35% to 39%). These findings are not surprising as single supplementation with potassium or vitamin K was rare and combination formulas used by our participants contained low levels of both micronutrients. Low values of vitamin K in MVMM products targeted for older adults may reflect the known drug-nutrient interactions of vitamin K with anticoagulant medication [32], while low levels of potassium may be attributable to the potential risk of serious adverse reactions associated with high intakes by individuals with impaired renal function or by those on potassium-sparing diuretics [55]. Overall, our data indicate that MVMM supplements could be better formulated to reduce the risk of inadequate intakes, with special consideration of magnesium, calcium, and vitamin D. Increasing levels of vitamin K or potassium in MVMM supplements should be cautioned as subpopulations of older adults are at increased risk of drug-nutrient interactions and adverse health effects from high intakes.

Despite the increasing availability of fortified foods and the high prevalence of supplement use, a majority of supplement users in our sample did not reach intake levels deemed excessive by the IOM/NAS. Only 4% of supplement users in our study exceeded the UL for folic acid from supplements and fortified foods; therefore, risk of high folic acid intakes masking vitamin B12 deficiencies [56] may not be a significant concern among the majority of older cancer survivors. Similarly, only 3% of supplement users exceeded the UL for calcium (>2500 mg). Nevertheless, guidelines recently issued by the World Cancer Research Fund and the American Institute for Cancer Research cautioned that calcium intakes of 1500 mg or more per day may be associated with elevated risk of aggressive prostate cancer [57]. Our findings revealed 27% of prostate cancer survivors who used dietary supplements had calcium intakes above 1500 mg per day, thus suggesting the need for increased guidance within this subgroup of cancer survivors. Indeed, the finding that only 5% of our sample met the AI for calcium from diet alone suggests that while supplementation might still be necessary for many older adults, special consideration regarding appropriate dose for prostate cancer survivors is warranted.

Approximately 10% of supplement users reported zinc intakes above the UL, which is comparable to an estimate from a previous investigation among older adults [9]. Prolonged consumption of high intakes of zinc has been associated with decreased high-density lipoprotein cholesterol, reduced copper status, and a weakened immune response [32]. Further, a recent study observed an increased risk of fatal prostate cancer among older men who used a zinc supplement in addition to an MVMM supplement more than seven times per week [28]. However, nearly one-half of the individuals who did not use supplements failed to meet the EAR for zinc; thus, a substantial proportion of elderly cancer survivors may benefit from supplemental zinc. Our data indicate that while the use of an MVMM product with a modest amount of zinc may benefit a sizable proportion of older adults, the use of an individual zinc supplement or an antioxidant combination product supplying high doses of zinc may pose potential health risks.

There are several strengths of the present study. The size of our sample and the distribution of survivors among three cancer types are two notable strengths compared to previous investigations of supplement use patterns among survivors, which tend to be limited to breast cancer survivors [46,58-61] or are comprised of smaller samples [5,46,58,59,62]. Despite consistently high supplement use rates observed across studies, supplemental intakes rarely are included in nutrient intake estimations, which likely results in underestimating total intake [63]. Further, the two telephone surveys included open-ended questions pertaining to supplement use, which allowed interviewers to capture components of combination supplements that might have been missed with close-ended questions (yes/no).

As in all studies, there are several limitations with the current investigation. One limitation to consider relates to sample and respondent bias. Our sample included a self-selected population of long-term, elderly survivors, who were predominantly white, well-educated, and interested in participating in a home-based diet and exercise program. Survivors who did not respond to the mailed study invitation may have differed from respondents with regards to demographic and lifestyle characteristics, as well as overall health, which may have influenced our findings. Given the variations in MVMM product composition [63], the use of a default nutrient profile likely overestimated supplemental intake for some individuals, while underestimating intake for others. The degree to which this biased our results is uncertain, as the error may have been randomly distributed. In addition, the true prevalence rate of dietary supplement use may be greater than estimated in our study because episodically consumed supplements could have been missed with only two dietary recalls. Lastly, the examination of multiple associations may have resulted in findings reaching statistical significance by chance alone.

Results from the present study indicate a high prevalence of dietary supplement use among elderly, long-term survivors of female breast, prostate, and colorectal cancer who are interested in lifestyle modification and health promotion. Elderly cancer survivors represent a rapidly growing population; thus, a better understanding of dietary supplement use and health-related behavior practices can provide valuable insight for the development of behavioral interventions and recommendations aimed at improving health outcomes among survivors [2]. Lastly, it is important to consider individual variability when developing recommendations concerning supplement use, as no single supplement is optimal for all older cancer survivors. Both individualized assessment and sound scientific evidence of efficacy and safety of product use should provide the foundation for the development of recommendations regarding dietary supplement use in this population.

References

1. Brenner H. Long-term survival rates of cancer patients achieved by the end of the 20th century: A period analysis. Lancet 2002;360:1131–5. [PubMed: 12387961]
2. Bellizzi KM, Rowland JH, Jeffery DD, McNeel T. Health behaviors of cancer survivors: Examining opportunities for cancer control intervention. J Clin Oncol 2005;23:8884–93. [PubMed: 16314649]
3. Coups EJ, Ostroff JS. A population-based estimate of the prevalence of behavioral risk factors among adult cancer survivors and noncancer controls. Prev Med 2005;40:702–11. [PubMed: 15850868]

4. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: Promoting long-term health after the diagnosis of cancer. J Clin Oncol 2005;23:5814–30. [PubMed: 16043830]
5. Patterson RE, Neuhouser ML, Hedderson MM, Schwartz SM, Standish LJ, Bowen DJ. Changes in diet, physical activity, and supplement use among adults diagnosed with cancer. J Am Diet Assoc 2003;103:323–8. [PubMed: 12616253]
6. Demark-Wahnefried W, Peterson B, McBride C, Lipkus I, Clipp E. Current health behaviors and readiness to pursue life-style changes among men and women diagnosed with early stage prostate and breast carcinomas. Cancer 2000;88:674–84. [PubMed: 10649263]
7. Dietary Supplement Health and Education Act of 1994. Pub l No.103-417, 108 Stat 4325 (codified at 21 USC 301).
8. NIH State-of-the-Science Conference Statement on multivitamin/mineral supplements and chronic disease prevention. NIH Consens State Sci Statements 2006;23:1–30.
9. Sebastian RS, Cleveland LE, Goldman JD, Moshfegh AJ. Older adults who use vitamin/mineral supplements differ from nonusers in nutrient intake adequacy and dietary attitudes. J Am Diet Assoc 2007;107:1322–32. [PubMed: 17659898]
10. Murphy SP, White KK, Park SY, Sharma S. Multivitamin-multimineral supplements' effect on total nutrient intake. Am J Clin Nutr 2007;85:280S–284S. [PubMed: 17209210]
11. Posner BM, Jette A, Smigelski C, Miller D, Mitchell P. Nutritional risk in new england elders. J Gerontol 1994;49:M123–32. [PubMed: 8169334]
12. Jensen GL, Kita K, Fish J, Heydt D, Frey C. Nutrition risk screening characteristics of rural older persons: Relation to functional limitations and health care charges. Am J Clin Nutr 1997;66:819–28. [PubMed: 9322556]
13. Rosenthal TC, Fox C. Access to health care for the rural elderly. JAMA 2000;284:2034–6. [PubMed: 11042733]
14. Miller DK, Carter ME, Sigmund RH, Smith JQ, Miller JP, Bentley JA, et al. Nutritional risk in inner-city-dwelling older black americans. J Am Geriatr Soc 1996;44:959–62. [PubMed: 8708308]
15. Saunders MJ. Nutrition and oral health in the elderly. Dent Clin North Am 1997;41:681–98. [PubMed: 9344273]
16. Roe DA. Drug and food interactions as they affect the nutrition of older individuals. Aging (Milano) 1993;5:51–3. [PubMed: 8399449]
17. Rock E, DeMichele A. Nutritional approaches to late toxicities of adjuvant chemotherapy in breast cancer survivors. J Nutr 2003;133:3785S–3793S. [PubMed: 14608115]
18. Tang BM, Eslick GD, Nowson C, Smith C, Bensoussan A. Use of calcium or calcium in combination with vitamin d supplementation to prevent fractures and bone loss in people aged 50 years and older: A meta-analysis. Lancet 2007;370:657–66. [PubMed: 17720017]
19. Brown JK, Byers T, Doyle C, Coumeya KS, Demark-Wahnefried W, Kushi LH, et al. Nutrition and physical activity during and after cancer treatment: An american cancer society guide for informed choices. CA Cancer J Clin 2003;53:268–91. [PubMed: 14570227]
20. The effect of vitamin e and beta carotene on the incidence of lung cancer and other cancers in male smokers. The alpha-tocopherol, beta carotene cancer prevention study group. N Engl J Med 1994;330:1029–35. [PubMed: 8127329]
21. Omenn GS, Goodman GE, Thornquist MD, Balmes J, Cullen MR, Glass A, et al. Effects of a combination of beta carotene and vitamin a on lung cancer and cardiovascular disease. N Engl J Med 1996;334:1150–5. [PubMed: 8602180]
22. Bjelakovic G, Nagorni A, Nikolova D, Simonetti RG, Bjelakovic M, Gluud C. Meta-analysis: Antioxidant supplements for primary and secondary prevention of colorectal adenoma. Aliment Pharmacol Ther 2006;24:281–91. [PubMed: 16842454]
23. Bjelakovic G, Nikolova D, Gluud LL, Simonetti RG, Gluud C. Mortality in randomized trials of antioxidant supplements for primary and secondary prevention: Systematic review and meta-analysis. JAMA 2007;297:842–57. [PubMed: 17327526]
24. Bjelakovic G, Nikolova D, Simonetti RG, Gluud C. Antioxidant supplements for prevention of gastrointestinal cancers: A systematic review and meta-analysis. Lancet 2004;364:1219–28. [PubMed: 15464182]

25. Bjelakovic G, Nikolova D, Simonetti RG, Gluud C. Antioxidant supplements for preventing gastrointestinal cancers. Cochrane Database Syst Rev. 2004CD004183
26. Forman D, Altman D. Vitamins to prevent cancer: Supplementary problems. Lancet 2004;364:1193–4. [PubMed: 15464163]
27. Sparreboom A, Cox MC, Acharya MR, Figg WD. Herbal remedies in the united states: Potential adverse interactions with anticancer agents. J Clin Oncol 2004;22:2489–503. [PubMed: 15197212]
28. Lawson KA, Wright ME, Subar A, Mouw T, Hollenbeck A, Schatzkin A, et al. Multivitamin use and risk of prostate cancer in the national institutes of health-aarp diet and health study. J Natl Cancer Inst 2007;99:754–64. [PubMed: 17505071]
29. Mulholland CA, Benford DJ. What is known about the safety of multivitamin-multimineral supplements for the generally healthy population? Theoretical basis for harm. Am J Clin Nutr 2007;85:318S–322S. [PubMed: 17209218]
30. Institute of medicine, food and nutrition board. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin b6, folate, vitamin b12, pantothenic acid, biotin, and choline. National academy press; Washington, dc: 2000.
31. Institute of medicine, food and nutrition board. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin d, and fluoride. National academy press; Washington, dc: 1997.
32. Institute of medicine, food and nutrition board. Dietary reference intakes for vitamin a, vitamin k, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. National academy press; Washington, dc: 2001.
33. Institute of medicine, food and nutrition board. Dietary reference intakes for vitamin c, vitamin e, selenium and carotenoids. National academy press; Washington, dc: 2000.
34. Demark-Wahnefried W, Clipp EC, McBride C, Lobach DF, Lipkus I, Peterson B, et al. Design of fresh start: A randomized trial of exercise and diet among cancer survivors. Med Sci Sports Exerc 2003;35:415–24. [PubMed: 12618570]
35. Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, Ritter PL. Champs physical activity questionnaire for older adults: Outcomes for interventions. Med Sci Sports Exerc 2001;33:1126–41. [PubMed: 11445760]
36. Casey PH, Goolsby SL, Lensing SY, Perloff BP, Bogle ML. The use of telephone interview methodology to obtain 24-hour dietary recalls. J Am Diet Assoc 1999;99:1406–11. [PubMed: 10570678]
37. Guenther, PM.; Reedy, J.; Krebs-Smith, SM.; Reeve, BB.; Basiotis, PP. Development and evaluation of the healthy eating index-2005: Technical report. Center for nutrition policy and promotion, u.S. Department of agriculture; [Accessed december 7, 2007]. 2007 Available at: Http://www.Cnpp.Usda.Gov/healthyeatingindex.Htm
38. Murphy SP, Poos MI. Dietary reference intakes: Summary of applications in dietary assessment. Public Health Nutr 2002;5:843–9. [PubMed: 12633508]
39. Velicer CM, Ulrich CM. Vitamin and mineral supplement use among us adults after cancer diagnosis: A systematic review. J Clin Oncol 2008;26:665–73. [PubMed: 18235127]
40. Radimer K, Bindewald B, Hughes J, Ervin B, Swanson C, Picciano MF. Dietary supplement use by us adults: Data from the national health and nutrition examination survey, 1999-2000. Am J Epidemiol 2004;160:339–49. [PubMed: 15286019]
41. Wiygul JB, Evans BR, Peterson BL, Polascik TJ, Walther PJ, Robertson CN, et al. Supplement use among men with prostate cancer. Urology 2005;66:161–6. [PubMed: 15992901]
42. McDavid K, Breslow RA, Radimer K. Vitamin/mineral supplementation among cancer survivors: 1987 and 1992 national health interview surveys. Nutr Cancer 2001;41:29–32. [PubMed: 12094625]
43. Foote JA, Murphy SP, Wilkens LR, Hankin JH, Henderson BE, Kolonel LN. Factors associated with dietary supplement use among healthy adults of five ethnicities: The multiethnic cohort study. Am J Epidemiol 2003;157:888–97. [PubMed: 12746241]
44. Sandler RS, Halabi S, Kaplan EB, Baron JA, Paskett E, Petrelli NJ. Use of vitamins, minerals, and nutritional supplements by participants in a chemoprevention trial. Cancer 2001;91:1040–5. [PubMed: 11251957]

45. Greenlee H, White E, Patterson RE, Kristal AR. Supplement use among cancer survivors in the vitamins and lifestyle (vital) study cohort. J Altern Complement Med 2004;10:660–6. [PubMed: 15353022]
46. Rock CL, Newman V, Flatt SW, Faerber S, Wright FA, Pierce JP. Nutrient intakes from foods and dietary supplements in women at risk for breast cancer recurrence. The women's healthy eating and living study group. Nutr Cancer 1997;29:133–9. [PubMed: 9427976]
47. Patterson RE, Neuhouser ML, White E, Hunt JR, Kristal AR. Cancer-related behavior of vitamin supplement users. Cancer Epidemiol Biomarkers Prev 1998;7:79–81. [PubMed: 9456246]
48. Kirk SF, Cade JE, Barrett JH, Conner M. Diet and lifestyle characteristics associated with dietary supplement use in women. Public Health Nutr 1999;2:69–73. [PubMed: 10452734]
49. Weinstein SJ, Vogt TM, Gerrior SA. Healthy eating index scores are associated with blood nutrient concentrations in the third national health and nutrition examination survey. J Am Diet Assoc 2004;104:576–84. [PubMed: 15054343]
50. Hann CS, Rock CL, King I, Drewnowski A. Validation of the healthy eating index with use of plasma biomarkers in a clinical sample of women. Am J Clin Nutr 2001;74:479–86. [PubMed: 11566646]
51. Kennedy ET, Ohls J, Carlson S, Fleming K. The healthy eating index: Design and applications. J Am Diet Assoc 1995;95:1103–8. [PubMed: 7560680]
52. Rock CL. Multivitamin-multimineral supplements: Who uses them? Am J Clin Nutr 2007;85:277S–279S. [PubMed: 17209209]
53. Weiss DR, O'Loughlin JL, Platt RW, Paradis G. Five-year predictors of physical activity decline among adults in low-income communities: A prospective study. Int J Behav Nutr Phys Act 2007;4:2. [PubMed: 17233904]
54. Di Francesco V, Zamboni M, Zoico E, Bortolani A, Maggi S, Bissoli L, et al. Relationships between leisure-time physical activity, obesity and disability in elderly men. Aging Clin Exp Res 2005;17:201–6. [PubMed: 16110732]
55. Institute of medicine, food and nutrition board. Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. National academy press; Washington, dc: 2004.
56. Sisk ER, Lockner DW, Wold R, Waters DL, Baumgartner RN. The impact of folic acid fortification of enriched grains on an elderly population: The new mexico aging process study. J Nutr Health Aging 2004;8:140–3. [PubMed: 15129298]
57. World cancer research fund, american institute for cancer research. Food, nutrition, and physical activity, and the prevention of cancer: A global perspective. American institute for cancer research; Washington, dc: 2007.
58. Fleischauer AT, Simonsen N, Arab L. Antioxidant supplements and risk of breast cancer recurrence and breast cancer-related mortality among postmenopausal women. Nutr Cancer 2003;46:15–22. [PubMed: 12925299]
59. Newman V, Rock CL, Faerber S, Flatt SW, Wright FA, Pierce JP. Dietary supplement use by women at risk for breast cancer recurrence. The women's healthy eating and living study group. J Am Diet Assoc 1998;98:285–92. [PubMed: 9508010]
60. Boon H, Stewart M, Kennard MA, Gray R, Sawka C, Brown JB, et al. Use of complementary/alternative medicine by breast cancer survivors in ontario: Prevalence and perceptions. J Clin Oncol 2000;18:2515–21. [PubMed: 10893281]
61. Stolzenberg-Solomon RZ, Chang SC, Leitzmann MF, Johnson KA, Johnson C, Buys SS, et al. Folate intake, alcohol use, and postmenopausal breast cancer risk in the prostate, lung, colorectal, and ovarian cancer screening trial. Am J Clin Nutr 2006;83:895–904. [PubMed: 16600944]
62. Patterson RE, Neuhouser ML, Hedderson MM, Schwartz SM, Standish LJ, Bowen DJ, et al. Types of alternative medicine used by patients with breast, colon, or prostate cancer: Predictors, motives, and costs. J Altern Complement Med 2002;8:477–85. [PubMed: 12230908]
63. Park SY, Murphy SP, Wilkens LR, Yamamoto JF, Kolonel LN. Allowing for variations in multivitamin supplement composition improves nutrient intake estimates for epidemiologic studies. J Nutr 2006;136:1359–64. [PubMed: 16614430]

Table 1

Relation of demographic, disease, and health-related characteristics with dietary supplement use by older cancer survivors (n = 753)

Characteristics	Total no. of participants	% participants reporting supplement use
	n	%
Age		
65-69y	231	69*
70+	522	77*
Gender		
Female	394	78**
Male	359	70**
Ethnicity		
White	669	75
Nonwhite	84	69
Cancer Type		
Female breast	321	80*
Colorectal	113	69*
Prostate	319	71*
Education		
< High school	56	64*
High school/GED	217	73*
Some college/college degree	356	74*
Professional/graduate degree	121	81*
Income		
≤ $30,000	219	71
>$30,000	467	76
No response	67	73
Stage at diagnosis		
Localized	523	75
Regional	203	74
Unknown	27	67
BMI[a]		
Overweight (25-30 kg/m^2)[b]	464	75
Obese (≥30 kg/m^2)	289	72
Tobacco use		
Current smoker	46	52**
Non-smoker	707	76**

* $P < 0.05$

** $P < 0.01$

[a] BMI = body mass index; calculated as kg/m^2

[b] Includes 11 individuals with BMIs from 22-24 because BMI was assessed twice as a part of a two tiered screening process; second measure was used

Table 2

Specific categories of supplements reported by supplement users, according to cancer site

Supplement categories	All supplement users (n = 559)		Breast cancer (n = 256)		Colorectal cancer (n = 78)		Prostate cancer (n = 225)	
	n	%	n	%	n	%	n	%
MVMM	446	80	200	78	62	79	184	82
Calcium, vitamin D, and combinations	277	50	167	65	40	51	90	22
Antioxidants[a]	231	41	98	38	32	41	101	45
Herbal/botanical	99	18	42	16	13	17	44	20
Other single vitamins	91	16	47	18	9	12	35	16
Other single minerals	52	9	28	11	5	6	19	8
Other single vitamin combinations	41	7	15	6	5	6	21	9
Other single mineral combinations	1	0.2	1	0.4	0	0	0	0
Fatty acids/fish oils/other oils	160	29	66	26	21	27	73	31
Amino acids/nucleic acids/proteins	30	5	13	5	1	1	16	7
Glucosamine, chondroitin, and combinations	106	19	38	15	16	20	52	23
Fiber (various types)	35	6	12	5	7	9	16	7

[a] Includes vitamins C and E, carotenoids, selenium, and related combinations

Table 3

Nutrient intakes and proportion of survivors below Estimated Average Requirements (EARs) and above Tolerable Upper Intake Levels (ULs)

	EAR male/female	Mean intake ± SD	Below EAR		Above UL	
			n	%	n	%
Vitamin A (RAE)	625/500					
Supplement nonusers[a]		690 ± 626	110	57[df]	1	0.5
Supplement users: dietary intake only[b]		703 ± 639	251	45[d]	5	1
Supplement users: dietary + supplemental intake[c]		1576 ± 937	47	8[f]	5	1
Vitamin E (alpha-tocopherol equivalents in mg)	12/12					
Supplement nonusers[a]		7.6 ± 5.8	167	86[f]	0	0
Supplement users: dietary intake only[b]		10.1 ± 11.4	451	81	0	0
Supplement users: dietary + supplemental intake[c]		86 ± 125	67	12[f]	0	0
Vitamin C (mg)	75/60					
Supplement nonusers[a]		63 ± 48	124	64[ef]	0	0
Supplement users: dietary intake only[b]		80.5 ± 53.8	261	47[e]	0	0
Supplement users: dietary + supplemental intake[c]		292 ± 379	52	9[f]	4	0.5
Vitamin B6 (mg)	1.4/1.3					
Supplement nonusers[a]		1.5 ± 0.7	91	47[f]	0	0
Supplement users: dietary intake only[b]		1.7 ± 0.9	229	41	0	0
Supplement users: dietary + supplemental intake[c]		8.0 ± 19.1	42	8[f]	13	2
Vitamin B12 (mcg)	2.0/2.0					
Supplement nonusers[a]		5.4 ± 7.9	33	17[f]	No UL	
Supplement users: dietary intake only[b]		4.8 ± 4.7	91	16		
Supplement users: dietary + supplemental intake[c]		99 ± 369	18	3[f]		
Folate (dietary folate equivalents (DFE))	320/320					
Supplement nonusers[a]		443 ± 235	67	35[df]	0	0
Supplement users: dietary intake only[b]		498 ± 285	147	26[d]	1	0.2
Supplement users: dietary + supplemental intake[c]		1078 ± 505	22	4[f]	22	4
Magnesium (mg)	350/265					
Supplement nonusers[a]		222 ± 85	174	90[ef]	0	0
Supplement users: dietary intake only[b]		246 ± 95	428	77[e]	0	0
Supplement users: dietary + supplemental intake[c]		338 ± 138	225	40[f]	10	2

	EAR male/female	Mean intake ± SD	Below EAR		Above UL	
			n	%	n	%
Zinc (mg)	9.4/6.8					
Supplement nonusers[a]		11.9 ± 17.4	92	48[f]	7	4
Supplement users: dietary intake only[b]		10.0 ± 6.4	222	40	4	1
Supplement users: dietary + supplemental intake[c]		25.5 ± 16.9	37	7[f]	48	9
Iron (mg)	6.0/5.0					
Supplement nonusers[a]		12.8 ± 5.9	9	5	0	0
Supplement users: dietary intake only[b]		13.8 ± 6.9	6	1	4	0.5
Supplement users: dietary + supplemental intake[c]		15.1 ± 17.3	6	1	8	1.5

[a] Supplement nonusers (n = 194); only dietary sources were used to calculate nutrient intake

[b] Supplement users: dietary intake only (n = 559); supplemental intake was excluded from nutrient intake

[c] Supplement users: dietary + supplemental intake (n = 559); supplemental intake was included in nutrient intake

[d] Significant differences noted between users and nonusers (dietary intake only); $P < 0.05$

[e] Significant differences noted between users and nonusers (dietary intake only); $P < 0.001$

[f] Significant differences noted between users and nonusers (dietary + supplemental intake); $P < 0.001$

Table 4

Nutrient intakes and proportion of survivors meeting Adequate Intakes (AIs) and above Tolerable Upper Intake Levels (ULs)

	AI male/female	Mean intake ± SD	Below EAR		Above UL	
			n	%	n	%
Vitamin D (mcg)	15/15					
Supplement nonusers[a]		4.3 ± 5.2	9	5[f]	1	0.5
Supplement users: dietary intake only[b]		4.3 ± 4.1	16	3	1	0.2
Supplement users: dietary + supplemental intake[c]		15.1 ± 7.8	306	55[f]	3	0.5
Vitamin K (mcg)	120/90					
Supplement nonusers[a]		102 ± 131	50	26[de]	No UL	
Supplement users: dietary intake only[b]		113 ± 115	198	35[d]		
Supplement users: dietary + supplemental intake[c]		121 ± 115	216	39[e]		
Calcium (mg)	1,200/1,200					
Supplement nonusers[a]		594 ± 289	186	4[f]	0	0
Supplement users: dietary intake only[b]		668 ± 350	33	6	2	0.5
Supplement users: dietary + supplemental intake[c]		1156 ± 593	205	37[f]	17	3
Potassium (mg)	4,700/4,700					
Supplement nonusers[a]		2161 ± 793	0	0	No UL	
Supplement users: dietary intake only[b]		2288 ± 781	6	1		
Supplement users: dietary + supplemental intake[c]		2368 ± 799	9	1.5		

[a] Supplement nonusers (n = 194); only dietary sources were used to calculate nutrient intake

[b] Supplement users: dietary intake only (n = 559); supplemental intake was excluded from nutrient intake

[c] Supplement users: dietary + supplemental intake (n = 559); supplemental intake was included in nutrient intake

[d] Significant differences noted between users and nonusers (dietary intake only); $P < 0.05$

[e] Significant differences noted between users and nonusers (dietary + supplemental intake); $P < 0.01$

[f] Significant differences noted between users and nonusers (dietary + supplemental intake); $P < 0.001$

Table 5

Factors associated with supplement use in multivariate logistic regression

	Odds Ratio[a]	95% Confidence Intervals
Age		
65-69y	1.00	
≥ 70y	1.70	(1.17, 2.46)
Gender		
Males	1.00	
Females	1.49	(1.04, 2.13)
Education		
< High school	1.00	
High school/GED	1.39	(0.79, 2.45)
Some college/college degree	1.47	(0.90, 2.51)
Professional/graduate degree	2.18	(1.13, 4.23)
Tobacco Use		
Non-smoker	1.00	
Current smoker	0.40	(0.21, 0.76)
HEI[b] Components		
Total Fruit	1.12	(1.01, 1.23)
Whole Grain	1.14	(1.04, 1.25)
Meat and Beans	0.81	(0.71, 0.93)
Oil	1.10	(1.01, 1.11)

[a]Odds ratios control for all other variables presented in table

[b]HEI = Healthy Eating Index